Building Research Establishment Digest

CI/SfB	DIGEST
81 (M2)	187

March 1976

Sound insulation of lightweight dwellings

This digest replaces Digest 96 which is now withdrawn.

This digest sets out the Station's present knowledge of sound insulation in dwellings gained from field measurements of industrialised systems of lightweight construction. The trend towards lightweight construction has made it necessary to develop ways of achieving adequate sound insulation other than simple recourse to weight, as in traditional houses. The alternative principles employed, notably structural isolation, are outlined. Practical forms of construction embodying these principles are discussed, against the background of established grades or standards of performance and the requirements of the building regulations. It is suggested that Digest 143 'Sound insulation: basic principles' should be read in conjunction with this digest.

Digests 102 and 103 are concerned with sound insulation between dwellings of basically traditional construction, in which the weight of the structural elements (separating and flanking elements) is by far the most important factor; performance standards or grades relating to walls and floors are suggested, and various traditional constructions are reviewed and graded.

Strictly speaking, no firm recommendation is made in Digests 102 and 103 respecting the choice of a standard, although for walls between houses the fact that only one criterion (the house party-wall grade) is nominated seems to imply that a lower standard would not be considered satisfactory. The British Standard Code of Practice* recommends the house party-wall grade in houses, but selects Grade 1 for walls and floors in flats.

Building regulations

The Building Regulations 1972 require only that a party wall or floor shall, in conjunction with its associated structure, provide 'adequate' resistance to the transmission of airborne sound and that a party floor between dwellings shall also (in conjunction with its associated structure) provide adequate resistance to the transmission of impact sound.

* CP 3: Chaper III: 1972, 'Sound insulation and noise reduction'.

For walls, the requirement is deemed-to-satisfy if measurements made and normalised in accordance with Scctions 2A and 3A of BS 2750 : 1956* show the transmission of airborne sound to be reduced by the amounts shown in Table 1. A tolerance not exceeding 23 dB total adverse deviation from the values shown, measured at all sixteen frequencies, is permitted.

Floors must meet the standards of Table 2, again with a permissible total adverse deviation of 23 dB each for airborne and impact sound.

The Building Standards (Scotland) (Consolidation) Regulations 1971, operative only in Scotland, set out in Part VIII precise minimum sound insulation performance standards for new dwellings, equivalent to the BRS house party-wall grade between houses and Grade I between flats.

The two sets of regulations differ in that, for England and Wales all party walls are expected to satisfy the house party-wall grade, while for Scotland this standard is only required between houses, the slightly lower standard of Grade I being acceptable in flats for party walls as well as for party floors.

* BS 2750 : 1956, 'Recommendations for field and laboratory measurement of airborne and impact sound transmission in buildings'.

Prepared at Building Research Station, Garston, Watford WD2 7JR
Technical enquiries arising from this Digest should be directed to Building Research Advisory Service at the above address.

Sound insulation grades

The three grading curves, party-wall grade, Grade I (Airborne sound) and Grade I (Impact sound), are shown in Tables 1 and 2. Grade II curves have no relevance to the present regulations, but they can be derived from the Grade I curves, being 5 dB worse at all frequencies for airborne sound and 6 dB worse at all frequencies for impact sound. In measured field results some spread is inevitable for any given construction, and a tolerance not exceeding 23 dB total adverse deviation from the grade curve measured at all sixteen $\frac{1}{3}$-octave frequency bands between 100 and 3150 Hz is, therefore, permitted in determining compliance with a particular grade.

The term 'party-wall grade' is used in this digest to denote the highest of the BRS grades, which was based on the average performance of normal one-brick solid party walls in traditional houses.

The BRS grades are related to field measurements, not to laboratory test results, which may be very different from field results of the same nominal constructions. The allocation of a grading to a type of construction should, whenever possible, be made on the average results of at least four examples, gradings of single examples being regarded as tentative.

Measurements of sound insulation for grading purposes can only be made between two rooms or enclosed spaces of a reverberant nature. Normally, the rooms will be on opposite sides of the party wall or floor, and it is convenient to quote the results as being the sound insulation of the wall or floor, although what is measured is not the insulation of the separating element alone, but the net reduction between the pair of rooms or dwellings via whatever transmission paths may happen to be present. Sometimes flanking transmission exceeds direct transmission and controls the measured reduction. This is the principal reason for large discrepancies between laboratory and field results for particular separating wall constructions. Measurements are affected by local conditions, such as furnishings, and for grading purposes all results are 'corrected' to conform to standardised furnished conditions, i.e. 0·5 sec. reverberation time in the receiving room.

Lightweight house construction

The most influential factor for sound insulation in conventional residential buildings is the weight of the structure, not only of the party wall or floor but of the flanking walls or floors as well, but it is well known that double-leaf walls can give insulation in excess of their weight contribution. Cavity party walls of plastered lightweight concrete blocks can show a saving of about 40 per cent of the weight of brick walling but this is not enough to satisfy modern demands. Moreover, the current move towards maximum factory prefabrication with rapid site erection calls for dry-construction techniques as well as for the lowest possible weight. Dry construction adds to the acoustic problem, because it is vital for sound insulation that all air-paths should be eliminated. Wet plastering, which could seal all joints and cracks, is currently out of favour and new developments in industrialised house construction have had to bear in mind the special need for efficient sealing. Sound insulation factors other than weight have had to be explored to the full.

Table 1 Party-wall grade

(Hz)	Minimum airborne sound reduction through wall (dB)
100	40
125	41
160	43
200	44
250	45
315	47
400	48
500	49
630	51
800	52
1000	53
1250	55
1600	56
2000	56
2500	56
3150	56

(Maximum total adverse deviation 23 dB)

Table 2 Grade 1

(Hz)	AIRBORNE SOUND minimum reduction through floor (dB)	IMPACT SOUND maximum octave-band sound pressure level under floor (dB)
100	36	63
125	38	64
160	39	65
200	41	66
250	43	66
315	44	66
400	46	66
500	48	66
630	49	65
800	51	64
1000	53	63
1250	54	61
1600	56	59
2000	56	57
2500	56	55
3150	56	53

(Maximum total adverse deviation 23 dB)

The essential requirements for good acoustic performance of dry lightweight construction are:

(a) an independent structure for each house;
(b) a double-leaf party wall construction;
(c) a certain minimum weight in each leaf;
(d) wide cavity separation between the two leaves.

The houses should be regarded basically as detached houses alongside each other. There is no objection to disguising them as a terraced row by

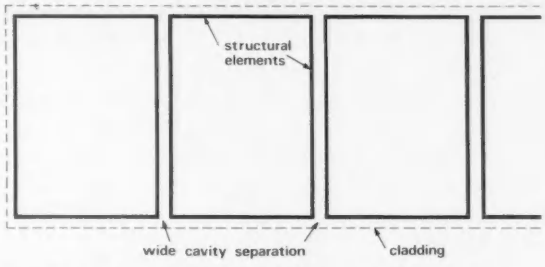

Fig. 1 Schematic plan of 'detached' terraced housing.

continuous claddings of suitable type with minimum acoustic continuity, but the houses should be self-contained structurally, as shown schematically in Fig. 1. They may be skeletal framed structures lined with prefabricated panels inside and out, or they may be constructed of loadbearing panels. The commonest system at present is the timber-framed structure, factory-made in storey-height sections and site assembled, linings being added either in the factory or on site. Typical details of a party wall of this construction are given in Fig. 2; the graph in Fig. 3 shows average performance and variability based on recent measurements of 28 party walls of this type.

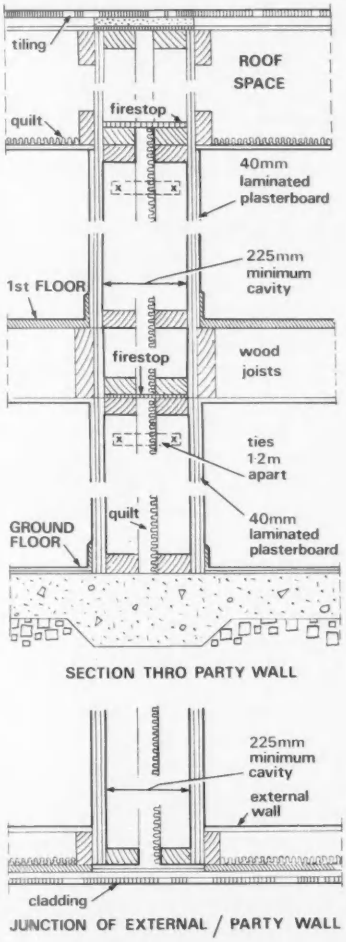

Fig. 2 Typical construction of party wall in isolated house system.

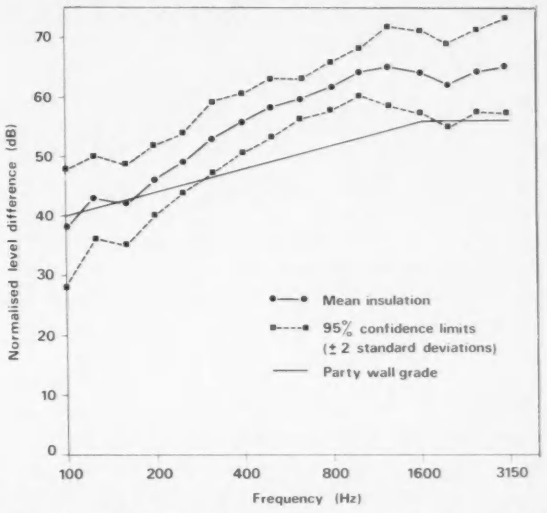

Fig. 3 Typical acoustic performance of isolated house systems.

A precise minimum weight for the leaves of the party wall cannot be given, but about 25 kg/m² is suggested as the minimum for each leaf, i.e. about 50 kg/m² for the double wall. This weight is exclusive of any framework, whether in timber, steel or concrete; it is the continuous weight of the linings or panels. The most common lining the Station has encountered, especially with timber-framed systems, is 40 mm thick laminated plasterboard. This may consist of two layers of 20 mm plasterboard, three layers of 13 mm, or four layers of 10 mm. The most common form is three layers of 13 mm plasterboard, two layers being glued together in the factory and pre-fixed to the timber-framed sections, the third layer being fixed *in situ* with the sheets laid in the opposite direction to the pre-fixed sheets. Recent tests on walls using one layer of 13 mm and one layer of 19 mm plasterboard seem to indicate that this also is satisfactory. This method should help to minimise the risk of joints between panels opening up in course of time and forming air-paths through the party wall.

Other panel materials of equal weight are likely to behave acoustically in much the same way, with minor variations in performance at different frequencies depending on the resonant properties; for practical purposes, the differences between the materials in normal use are not thought to be significant. Considerations such as thermal and moisture movements should be kept in mind, however, because of the serious acoustic effects that could arise from the joints opening up; obviously, the material must be robust enough to withstand mechanical damage.

The width of the separating cavity cannot be fixed very precisely, but 225 mm seems to be about right as a minimum dimension. Making the cavity wider is beneficial. Cavity width is measured between the backs of the lining panels; supporting framework up

to, say, 15 per cent of the panel area may project into the cavity, providing it does not touch the opposite frame. It is quite possible that the weight of the leaves and the width of the cavity are linked, since both are relevant to the critical problems of sound insulation performance at low frequencies, i.e. the bottom octave (100–200 Hz) of the range we are concerned with. If so, it may be possible to reduce the cavity a little provided the weight of the leaves is increased to compensate; however, it may be necessary to increase the weight by at least 50 per cent each time the cavity is reduced by 25 mm.

Cavities or air-spaces are more effective for sound insulation if they contain a reasonable amount of sound absorbent material, especially if the cavity is a wide one designed to make a significant contribution to the total performance. As most panels will present a fairly hard reflecting surface to the cavity, the insertion of a sound absorbent quilt or blanket is recommended to provide the necessary absorption. Almost any standard glass-wool or mineral-wool quilt 13–25 mm thick will serve, except that any paper covering should be limited to one side of the quilt only. The quilt is usually suspended in the cavity by stapling it to the frame on one side. Its position in the cavity is not important. In platform-type timber-framed construction the provision of two quilts, one on each side of the cavity and firmly attached to the timber frame, contributes to fire-resistance and may dispense with the need for ties bridging the cavity.

Structural isolation

The important matter of the structural independence of adjoining houses needs to be considered in more detail. For effective sound insulation, complete isolation above ground level should be the aim, but this often conflicts with other functional needs, such as stability and fire protection, which may call for bridging of the cavity. Weather protection at the ends of the party wall may also bridge the cavity. Fortunately some forms of bridging, applied with restraint, give the required standard of sound insulation. For example, normal roof tiling can safely be carried across the top of the party wall provided the cavity extends up to the underside of the tiling. Fire protection regulations require the top of the wall to be sealed against the passage of fire from one side to the other; to comply with this, roof tiling needs to be bedded on non-combustible material (e.g. mortar) which is usually supported over the cavity by asbestos-board. This construction is acceptable acoustically. Similarly, an asbestos-board bridge inserted across the cavity at first-floor level as a fire-stop can be accepted; best results are likely to be obtained if it is fixed to the structural frame on one side only or not fixed at all but simply left resting on the horizontal members of the timber frames.

In two-storey housing, the fire requirement across the party wall is one hour's fire resistance. Within a two-storey house of single occupancy, the required fire-protection standard for the first-floor construction is half an hour. This difference raises a special problem in timber-framed houses of 'platform' construction, because collapse of the floor at the end of half an hour could cause premature collapse of the supporting leaf of the party wall, exposing to the fire the timber frame of the other leaf. Structural stability is thus a contributory factor in fire resistance. A method of safeguarding stability employed in some systems is to tie the timber frames of the party wall together by a row of metal straps 1·2 m. part just below each ceiling level. The straps are usually 40 mm by 3 mm flat steel bar nailed or screwed to the sides of the timber studs. These ties seem to have no serious effect on sound insulation, though this may not continue to be the case if the number of ties is increased beyond the dozen or so used in the houses tested.

Floors in flats

The type of house construction discussed so far can, of course, be used for two- or three-storey flatted dwellings, but in that case the floors also have to reach a certain standard of sound insulation, and requirements for impact sound reduction as well as for airborne sound reduction must be satisfied. If the building is timber-framed or a very light steel-framed structure, concrete floors may not be feasible and a joisted floor may be the only appropriate type.

It is known that a Grade I standard of sound insulation is unlikely to be achieved with wood joist floors in traditional structures (except with very heavy supporting walls) because of flanking transmission. It is not clear whether flanking transmission is also a problem in timber-framed structures. Some tests done by BRE have shown that it is possible to achieve Grade I performance with timber joist floors in timber-framed structures but there is not yet sufficient evidence on which to base detailed guidance.

Department of the Environment **Building Research Establishment**

© *Crown copyright 1976*

Published by Her Majesty's Stationery Office and printed in England by Benham and Company Limited, Colchester.
Single copies 7p each. Annual subscription inclusive of postage £2·25 for 12 monthly issues and new editions of earlier Digests. Quantity rates excluding postage for bulk supply of any one Digest: 25 for £1·47, 50 for £2·31, 100 for £4·20.

Dmd. 289407 K608 3/76 ISBN 011 721711 5